Cropping systems influence erosion risk in northern Thailand highlands

The problem

• In Southeast Asia, highland cropping and farming systems are diversifying rapidly due to high population growth and accelerated integration into the market economy. In upper northern Thailand, the very limited adoption of station-proven erosion control techniques shows that the traditional biophysical approach to erosion research relying on researcher-controlled runoff plots and long-term experiments is no longer adapted to these new circumstances.

• To better deal with the extensive spatial heterogeneity and temporal variability typical of the montane environment, new integrated on-farm R&D approaches are needed to assess the influence of the increasing diversity of farmers' practices on erosion risk. To be effective, such alternative approaches should be based on an understanding of actual erosion processes in farmers' fields.

Research objectives

• At the field level: to understand the causal relationships between erosion and physiographic and climatic conditions and agronomic practices across an extensive range of on-farm situations,

• At the catchment level: to understand the spatial distribution of major erosion damage.

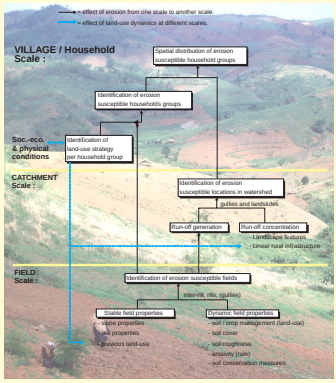
Catchment and on-farm erosion surveys: two complementary tools

• At the field level, a 2-year (1994-95) on-farm erosion survey covering an extensive range of slopes, rainfall and cropping systems was conducted in a single highland village to understand their relationships with the appearance of rill erosion.

• All the observations were made in hydrologically isolated monitoring zones in 48 farmers' fields (10 m wide x 11–67 m long) visited after each significant rain event.

• At the catchment level, three catchments (some 100 ha each) were surveyed to identify, analyze and rank the causes of larger erosion symptoms.

• At the farm level, the functioning of the different household-based farming systems was analyzed to elucidate the relationships between farm type and erosion risk (results not presented).



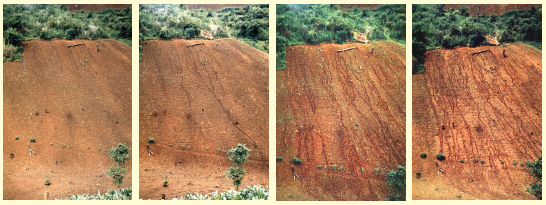
The proposed multiscale approach for on-farm erosion research

The study site

Pakha Sukjai, a highland Akha village (800–1100 masl) in extreme northern Thailand, with some 65 inhabitants km^{-2}, is characterized by a monsoon climate (1600–2200 mm rainfall year^{-1}), a strong relief (slope angles of 30–70%), phyllite-derived soils and diverse cropping systems managed on a semi-permanent basis.

Selected results at field-plot scale

• **Least erosive rain event:** A storm of at least 11 mm, a minimum erosivity value of 53 MJ mm ha^{-1} h^{-1}, a minimum 30 min intensity I_{30} of 15 mm h^{-1} and a duration of at least 37 min were necessary to generate visually detectable erosion symptoms at Pakha Sukjai. For daily amounts of 20 mm and more, new erosion symptoms were always observed (Turkelboom and Trébuil 1998).



June 1, 1994 *June 4* *June 11* *June 14*

• ***Typology of erosion symptoms:*** The correspondence between the diagnosed five stages of erosion severity and calculated soil losses is a useful tool for roughly but rapidly assessing soil losses at the field level in this study area.

Relationship between calculated soil losses and observed erosion in Pakha Sukjai, Chiang Rai province, upper northern Thailand; 1994 and 1995 wet seasons (UR = upland rice, Mz = maize, Bn = bean)

	Obs. year	Crop	Calculated soil loss t ha^{-1} yr^{-1}	Plough-layer erosion	Red rills	Rill network	Pre-rill network	Pre-rills or occasional rills
Stage 5: Very severe erosion (150–350 t ha^{-1} crop^{-1})	1995	UR	350	x	x	x		
	1994	UR	270	x	x	x	x	
Plough-layer erosion at the bottom of	1994	Mz	229	x	x	x	x	
the field by widening rills or planar slides	1994	UR	187	x	x	x		
Stage 4: Severe erosion (100–150 t ha^{-1} crop^{-1})	1994	UR	145	(x)	x	x	x	
	1994	UR	108	(x)	x	x	x	
Several active red rills and plough-layer erosion at some local spots								
Stage 3: Moderate erosion (20–100 t ha^{-1} crop^{-1})	1994	Bn	64		x	x		
	1995	UR	61			x		
Presence of rill network (> 5 rills per	1994	UR	60		x	x	x	
10-m contour) or presence of red rills	1994	Mz	36		x	x	x	
Stage 2: Mild erosion (5–20 t ha^{-1} crop^{-1})	1994	Bn	20				x	
	1995	Bn	18				x	
Presence of a pre-rill network	1994	UR	17				x	
(> 5 pre-rills per 10-m contour)	1995	Mz	13				x	
or several active rills	1995	UR	10				x	
(> 3 per 10-m contour)	1995	Mz	10				x	
	1994	Bn	10				x	
	1994	UR	7				x	
	1994	Mz	6				x	
	1995	UR	6					x
	1995	Bn	5				x	
Stage 1: Very mild erosion (0–5 t ha^{-1} crop^{-1}) Occasional rills	1995	Mz	4					x
	1995	UR	2					x
(1–2 per 10-m contour and a low	1995	Mz	2					x
density ofpre-rills (< 5 per 10-m contour)	1995	UR	2					x

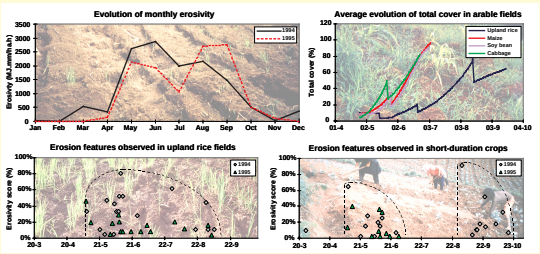
• ***Thresholds for slope angles and lengths***: Rills could be observed in nearly every field. Plough-layer erosion started to be observed in fields with slope angles and lengths superior to 47% and 25 m, respectively.

Relationship between calculated soil losses, type of erosion features and slope characteristics in Pakha Sukjai watershed

Slope length threshold	Slope angle threshold > 57%	Slope angle threshold 47–57%	Slope angle threshold < 47%
> 25 m	**Plough-layer erosion / high risk** Maximum observed: 350 t ha^{-1} crop^{-1}	**Plough-layer erosion / medium risk** Maximum observed: 270 t ha^{-1} crop^{-1}	**Rill network and deep "red" rill** Maximum observed: 61 t ha^{-1} crop^{-1}
< 25 m	**Rill network** Maximum observed: 64 t ha^{-1} crop^{-1}	**Pre-rill network** Maximum observed: 20 t ha^{-1} crop^{-1}	**Pre-rill network** Maximum observed: 10 t ha^{-1} crop^{-1}

• ***Thresholds for soil cover*** : Above 50% of total soil cover and 30% of contact cover erosion was negligible. These thresholds were applied to delimit the duration of the 'critical periods' for erosion, when field management practices can have a major impact on erosion via their effects on weed and residue cover.

• ***Delimitation of critical periods for the main cropping systems*** : For a given storm, an erosivity of 100% means that the maximum increase in erosion (from least severe type to the most severe one) was observed in all the monitored fields. Results show that upland rice displays a long period of susceptibility to erosion of some 4 months, whereas for maize, beans and cabbage the critical period lasts a maximum of 1.5 months. This is related to very differing evolutions of total soil cover between upland rice and other shorter duration crops.



Identification of critical periods for soil erosion in Pakha Sukjai for 1994 and 1995 wet seasons

Delimitation of the high-erosion-risk domain

• Integration of the above-mentioned thresholds and the fallow effect (litte erosion in new fields after clearing) allows us to identify the field combinations corresponding to high erosion risk.

Effects of slope characteristics, soil cover and field history on the risk of erosion by concentrated flow in Pakha Sukjai, Chiang Rai province, upper northern Thailand (n= 330, 1994 and 1995 wet seasons).

Soil critical cover	Field history	Slope characteristics < 47% <25m	< 47% >25m	47-57% <25m	47-57% >25m	>57% <25m	>57% >25m
< critical cover	Fallow clearing	18*		7	7	25	50
	Old field	43	27	14	50	33	51

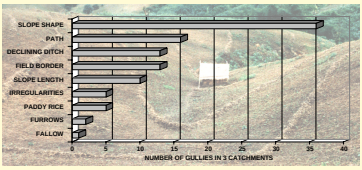
** Percentage of field observations in the given situation for which worsening erosion was found compared to the previous field visit.*

• This matrix is useful in planning and testing appropriate improvements in cropping systems management and land use with farmers, and in providing local stakeholders and decision-makers with a spatial distribution in the watershed of the erosion risk measured at the field level (Trébuil et al 1997).

Causes of major erosion damage at the catchment scale

• Because of the mosaic of land use of small fields and fallows and rural infrastructure interrupting runoff flows, only 10% of the gullies observed were developed from rills in long fields or when runoff could flow from one field into another.

• Runoff concentration took place mainly as the result of contour concavity in 36% of the cases or rural infrastructure in 49% of the cases.



Identification of factors causing gullies at catchment scale in Pakha Sukjai during the 1995 wet season

Conclusions

• The multiscale erosion survey approach is a fast and cheap way to generate new knowledge about erosion processes in the context of diverse farming situations. As all observations are made in actual farmers' circumstances and aim at understanding the key processes at work, the outputs are very relevant for addressing local problems.

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